FINAL REPORT

A System for

COMPUTER-ASSISTED DEFOLIATION MAPPING

FROM DIGITIZED COLOR INFRARED (CIR) VIDEO IMAGERY

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February, 1990

What Was Proposed

Our March 24, 1988 proposal listed the following functions as elements of the microcomputer image analysis system which would be programmed:

1. Capture and re-display individual video frames from VCR input.
2. Modify the captured scene with a variety of digital image enhancements such as contrast stretching and spatial filtering.
3. Use a mouse (graphic pointing device) to delineate areas of defoliation in the scene as shown on the monitor screen.
4. Interactively label each of the previously delimited map units.
5. Link the labeled polygons to a relational data base management system.
6. Geometrically rectify the defoliation polygons to existing digital basemap files from the Michigan Department of Natural Resources (MDNR).
7. Calculate the areas, by defoliation class, of the delimited map units.
8. Mosaic the digital maps derived from the individual video scenes into a larger-area (i.e. township, county, or multi-county) digital file.
9. Plot the digital defoliation map on a pen plotter and laser printer.
10. Digital map files created by this process will be available for external GIS display and analysis.

What Was Accomplished

As of the close of this contract, nine of the ten functions have been implemented. After initial testing, it became obvious that there was not a pressing need for "a variety of digital image enhancements such as contrast stretching and spatial filtering." As a matter of fact, our evaluations suggest that in most landscapes defoliation greater than about 50% foliage loss is relatively easy to detect and delineate on the S-VHS CIR video data which the MDNR is currently using. More to the point, such image processing severely reduces the operational throughput capability of the final system. To the best of our knowledge, nothing short of a very expensive ($6,000 - $7,00) real-time image processing board could provide the speed necessary to enhance these images given the vast number of frames which must be processed. Since such enhancements appears to be largely unnecessary and are too time consuming, this function objective was deleted from the project objectives.

System Description

The Video-image Processing system (Videodig) created for this project was written as a new module in the C-Map program that has been developed at the Center For Remote Sensing, Michigan State University over the last few years (see Appendix 1). C-Map is a micro-computer mapping program that provides entry, display, update, and analysis capabilities for both spatial and non-spatial data. It is specifically designed to use the digital map data from the MDNR Michigan Resource Information System (MIRIS). C-Map is a vector-based program built on the Halo[tm] Graphics Library (Media Cybernetics); it stores attribute data in dBASE-compatible files. Figure 1 shows the overall organization and menu environment of C-Map. Note that the video processing module is one of five components of the Digitize subroutine of C-Map.

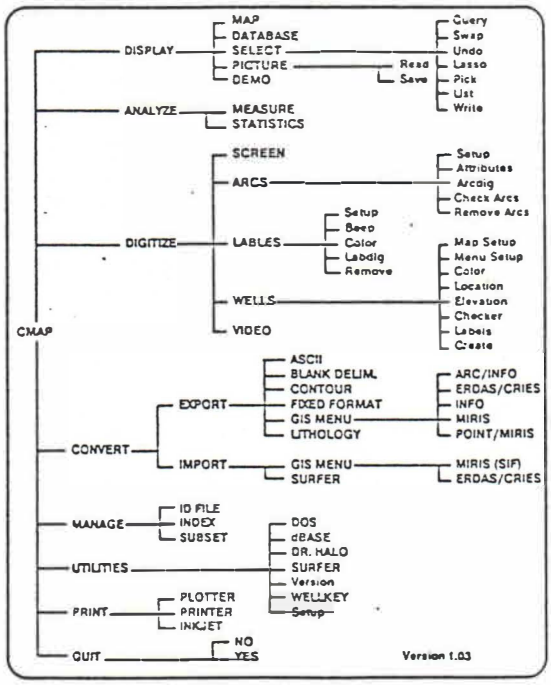


Figure 1. C-Map organization and menu environment.

Once the operator selects the Digitize and Videodig options in the menu, they are presented with the video processing menu (Figure 2). For capture and display of video images, the system uses the TARGA 16 graphics board from Truevision, Inc. This product supports a spatial resolution of 512 by 482 pixels at a color resolution of 16 bits per pixel -- 5 bits for each color channel (RGB) plus 1 overlay bit. The TARGA 16 board captures (i.e. digitizes) composite NTSC video input in real time. In the Videodig subroutine, this is accomplished by selecting Capture with the cursor and responding Y. This action places the hardware in a capture-standby mode. The actual digitization, which occurs in 0.033 seconds, is triggered by pressing the space bar. Once an image has been captured, it may be displayed at a later time using the Display command from the Videodig menu. Figure 3 shows a captured video image displayed on the monitor; most of the blue-grey areas in this image are defoliated.

```
IM V I D E O D I G:  Video Digitizing ##########################################
:                                                                              :
:                                  15:22:33                                    :
:                                                                              :
: VIDEO              SAMPLE              DATA              DIGITIZE            :
:                                                                              :
: Capture: n         Frame:     1        File: rept150     Areas:  Y           :
:                                                                              :
: Display: Y         Roll:      1        Draw: n           Lines:  N           :
:                                                                              :
: Save: n            Sect:      1        Query: n          Points: N           :
:                                                                              :
: Blank: n           Twsp:      1        Attributes: n                         :
:                                                                              :
:                    Date:  06/24/89     DOS: n            MapSetup:  Y        :
:                                                          Key O Set Options   :
:                                                                              :
: Directory> D:\TARGA                                      Sequence: n         :
: ---------------------------------------------------------------------------- :
```

Figure 2. The Videodig menu in C-Map, highlighting Capture and Display.

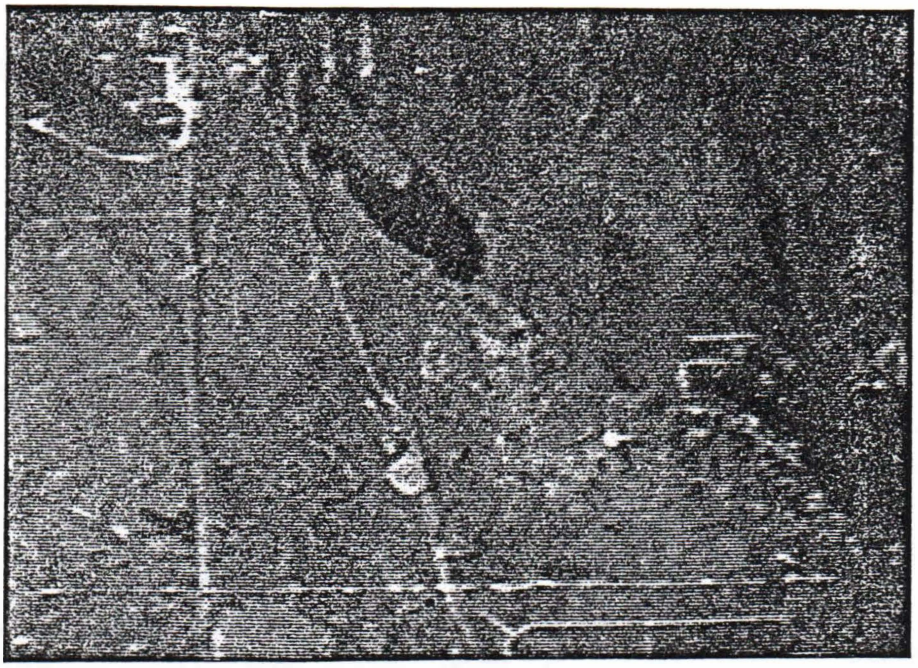


Figure 3. Display of a digitized CIR video image from central Clare County, Michigan showing numerous areas of defoliation.

The next step in the analysis process is to georeference the image. In Michigan we are fortunate to have MIRIS digital basemaps for almost the whole state. These digital, vector maps were digitized by the MDNR from U.S.G.S. 7.5-minute quadrangles; they include all the cartographic detail of the original quadrangle except the green woodland overprint, the contour lines, and the individual structure symbols. The availability of these data means that once a digitized video image has been georeferenced, selected elements of the digital basemap can be drawn onto the raster image as an overlay.

From the Videodig menu, the MapSetup option is selected (Figure 4). During this phase, the operator is prompted to enter the coordinates of four points which can be clearly defined in the image. These coordinates usually are determined from a 7.5-minute quadrangle. Using a mouse pointing device, the operator is prompted to locate

and mark the position of the four ground control points in the scene. The hardware zoom (2x, 4x, 8x) and pan functions greatly facilitate this procedure. Figure 5 shows the four ground control points used to georeference the Lake George scene. Currently, the coordinate transformation is being accomplished with a first-order polynomial function.

```
IM V I D E O D I G:  Video Digitizing ##########################################################
:                                                                                              :
:                                      15:22:33                                                :
:                                                                                              :
: VIDEO                SAMPLE                DATA                  DIGITIZE                  :
:                                                                                              :
: Capture: n           Frame:     1          File: rept150         Areas:  Y                 :
:                                                                                              :
: Display: Y           Roll:      1          Draw: n               Lines:  N                 :
:                                                                                              :
: Save: n              Sect:      1          Query: n              Points: N                 :
:                                                                                              :
: Blank: n             Twsp:      1          Attributes: n                                   :
:                                                                                              :
:                      Date:  06/24/89       DOS: n                MapSetup:  Y              :
:                                                                  Key O Set Options           :
:                                                                                              :
: Directory> D:\TARGA                                              Sequence: n               :
: ---------------------------------------------------------------------------------------------
```

Figure 4. The Videodig menu in C-Map, highlighting MapSetup.

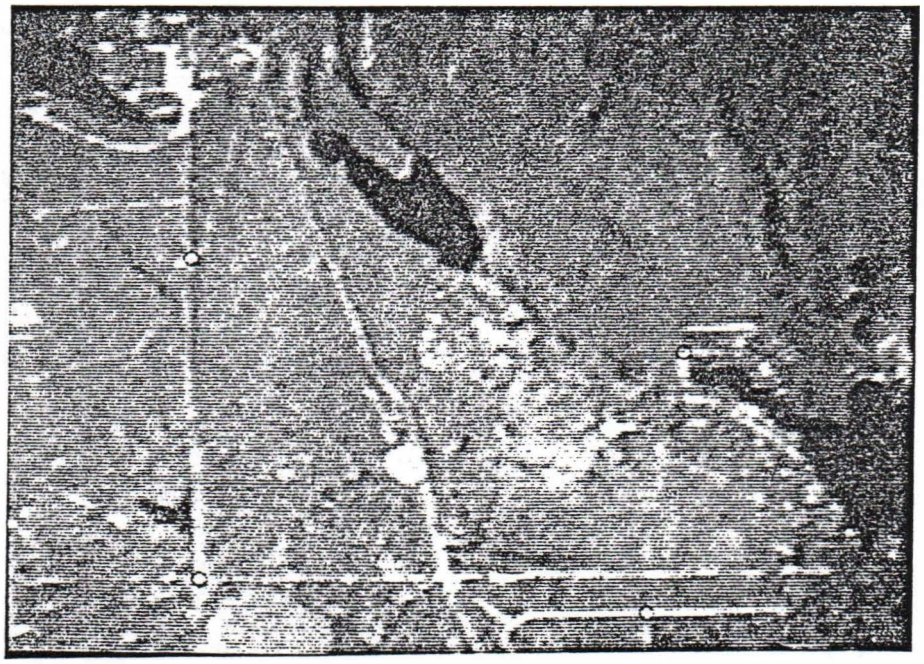


Figure 5. Four ground control points marked in the Lake George scene; the state plane coordinates of these locations were used to georeference this scene.

After entering the last of the four ground control points (GCPs), the software provides an error-budget statement (Figure 6) which assists the operator in determining the accuracy of the setup. In low-relief terrain, the first-order transformation has typically provided sub-pixel registration accuracies. In addition to the error-budget, the accuracy of a setup may also be checked by overlaying some of the MIRIS digital basemap data

onto the scene and visually assessing the "fit". Figure 7 shows the MIRIS vector data for railroads, pipelines, and local roads overlaid onto the Lake George scene. The largest disparity between the scene detail and the vector data occurs at the zig-zag in the pipeline clearance near the center of the scene. This location is on top of a hill which is about 18 to 21 meters higher than the average elevation of the four GCPs. This "fit" is still very serviceable considering the accuracy requirements of defoliation mapping. Of course, the best feasible accuracy is desired so that GIS overlay analyses can be conducted in the future without undue concern.

```
Units per Pixel in X-Direction:       19.24

Units per Pixel in Y-Direction:       17.47

The Average Pixel Dimension is:       18.35

The average error calculated for this setup is 7.99 feet.

The Standard Deviation is: 0.88

      X-Coord        Y-Coord      X-Error    Y-Error    D-Error

1.  1845902.00     227513.00      -3.44       8.57       9.23 <- Beyond 1 Std. Dev.
2.  1850989.00     226367.00       2.79      -6.95       7.49
3.  1850547.00     223560.00      -2.57       6.40       6.90
4.  1845839.00     224038.00       3.11      -7.75       8.35


Is this amount of error acceptable? (y or n) [YES]:
```

Figure 6. Example error-budget statement from Videodig-MapSetup.

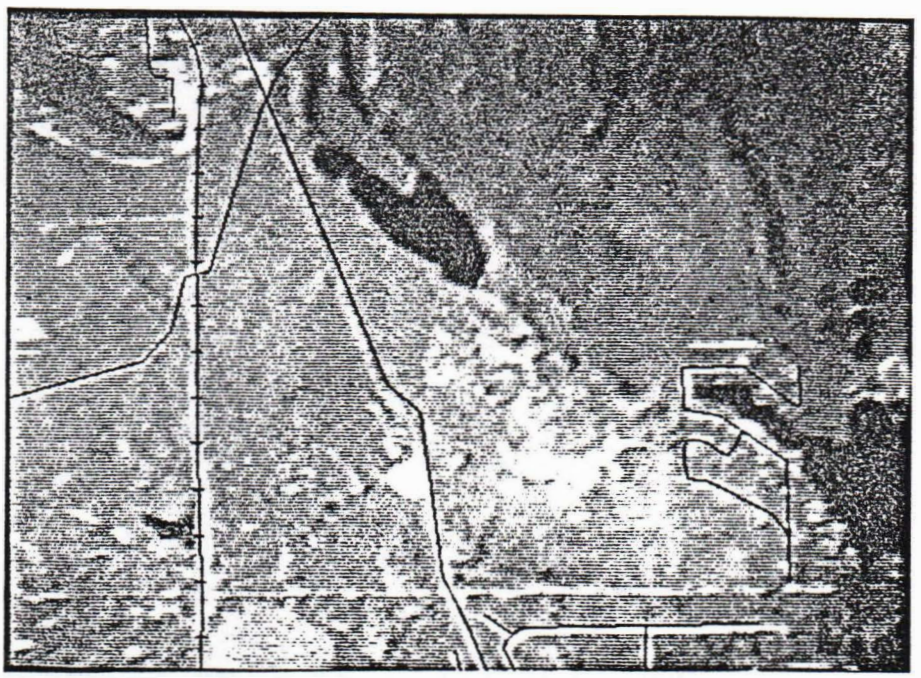


Figure 7. MIRIS vector data for railroads, pipelines, and local roads overlaid onto the Lake George scene after georeferencing.

The next step in the video analysis process is to assign a name for the file and then to delineate the various polygons of defoliation in the scene. This on-screen drawing is done with the mouse pointing device and is activated by the Area option in the Videodig menu (Figure 8). Each polygon is automatically assigned a unique ID number. The pan and zoom functions greatly facilitate this delineation process. One delimited defoliation polygon, with its unique sequence number, is shown at 2x magnification in Figure 9.

```
IH V I D E O D I G:  Video Digitizing HHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHH;
:                                                                              :
:                                  15:22:33                                    :
:                                                                              :
: VIDEO              SAMPLE              DATA              DIGITIZE            :
:                                                                              :
: Capture: n         Frame:    1         File: rept150     Areas:  Y           :
:                                                                              :
: Display: Y         Roll:     1         Draw: n           Lines:  N           :
:                                                                              :
: Save: n            Sect:     1         Query: n          Points: N           :
:                                                                              :
: Blank: n           Twsp:     1         Attributes: n                         :
:                                                                              :
:                    Date:  06/24/89     DOS: n            MapSetup:  Y        :
:                                                         Key O Set Options    :
:                                                                              :
: Directory> D:\TARGA                                     Sequence: n          :
: ---------------------------------------------------------------------------- :
:                                                                              :
: [AREAS]  <L>Pts <M>End <R>BackUp      AREA:            NUM   10            :
:                  Digitize next object. Mouse is active...                    :
: Press <Esc> Key to UNDO a line or QUIT.                                      :
HHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHH<
 <Ins>Zoom <>Coarse Roam <Ctrl>+<[,PgUp,PgDn]>Fine Roam <Esc>Quit
```

Figure 8. Videodig menu of C-Map, highlighting the Area option.

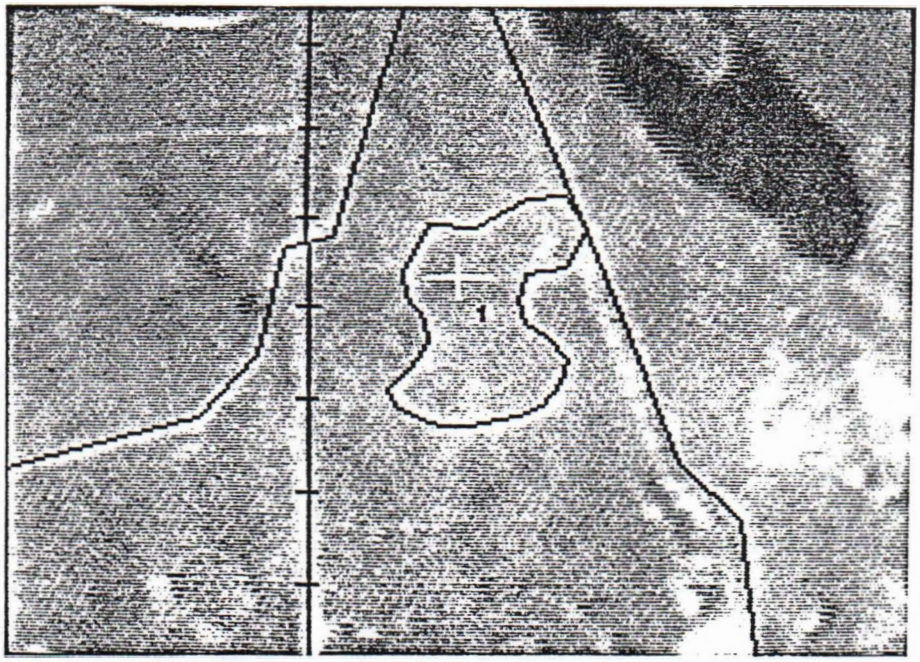


Figure 9. Delineated polygon of defoliation displayed at 2x magnification.

In addition to the digital basemap data from MIRIS, for most counties in the state there is also a digital land cover map available. These data can be very useful during the process of identifying and delimiting defoliation areas. Wetlands and some coniferous stands are two of the most likely targets to be confused with defoliated broadleaf trees. Displaying the MIRIS land cover data onto the raster video image as a reference file can assist the interpreter in several ways. First, it restricts the operator's attention to the arboreal communities only. Secondly, it helps the interpreter recognize confusion areas and develop for themselves workable mapping criteria. Thirdly, it can assist managers and researchers to discover environmental patterns to the defoliation which may have gone unnoticed otherwise. Figure 10 is a 2x magnification of a segment of the Lake George scene showing MIRIS vector land cover data (in white) and three video-digitized polygons of defoliation (in black). In the upper left corner of the scene, note how the presence of the MIRIS polygon 612 (Forested Wetland) assists the interpreter in excluding this area from the defoliation polygon.

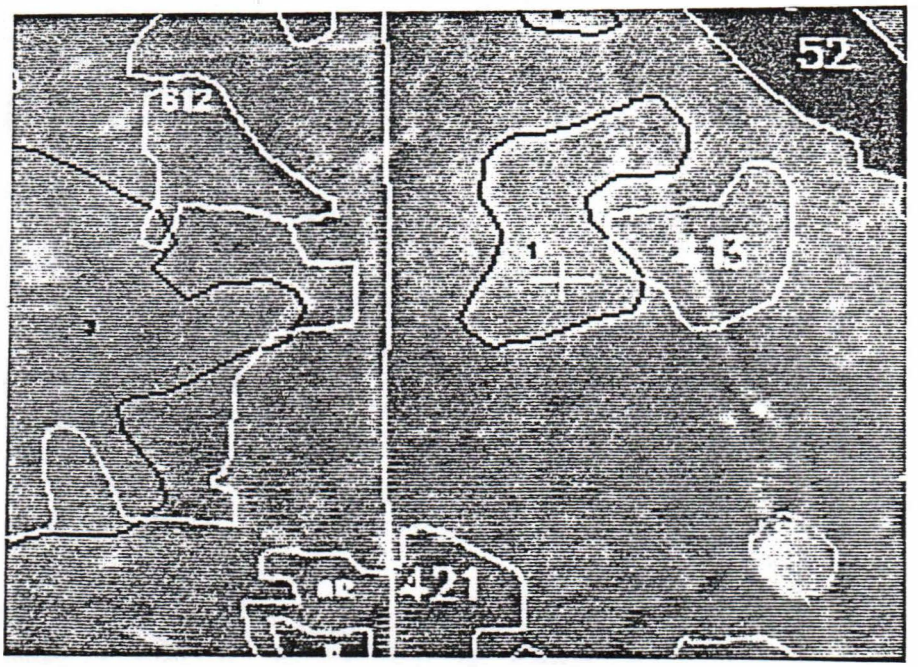


Figure 10. 2x magnification of the west-central portion of the Lake George scene showing existing MIRIS land cover data (in white) overlaid on the image along with video-digitized polygons of defoliation (in black).

For comparison purposes, Figure 11 shows the various areas of defoliation delimited in the Lake George scene using Videodig while Figure 12 shows these same data overlaid with the MIRIS land cover data. A number of useful GIS analyses would be possible in the second case such as calculating the area of defoliation by cover class. Also, if defoliation polygons from previous years were topologically overlaid, then a map indicating one factor of mortality risk could be produced.

Figure 11. Several defoliation polygons which were digitized onto the Lake George scene using C-Map Videodig.

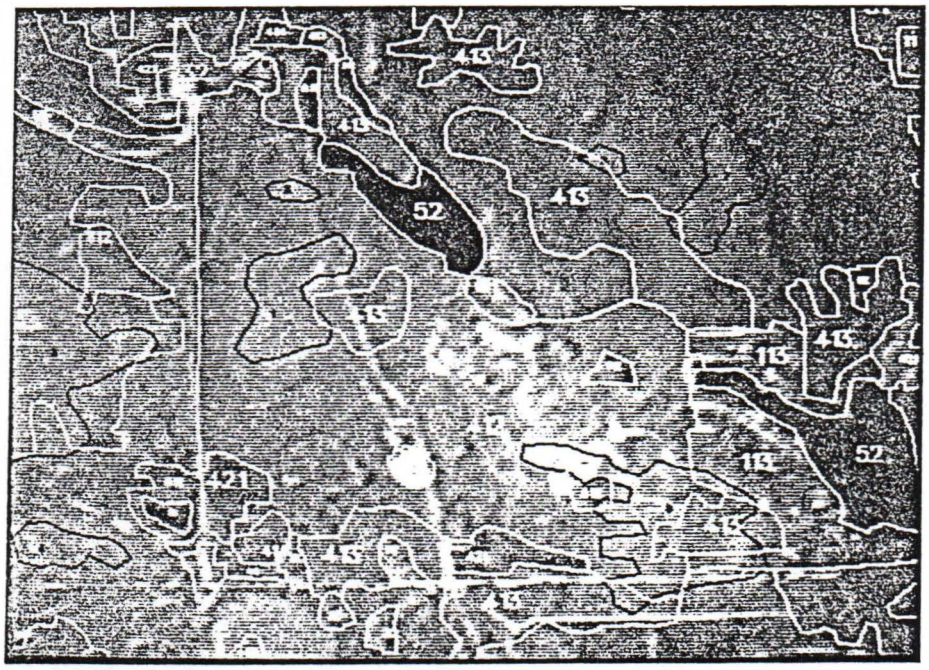
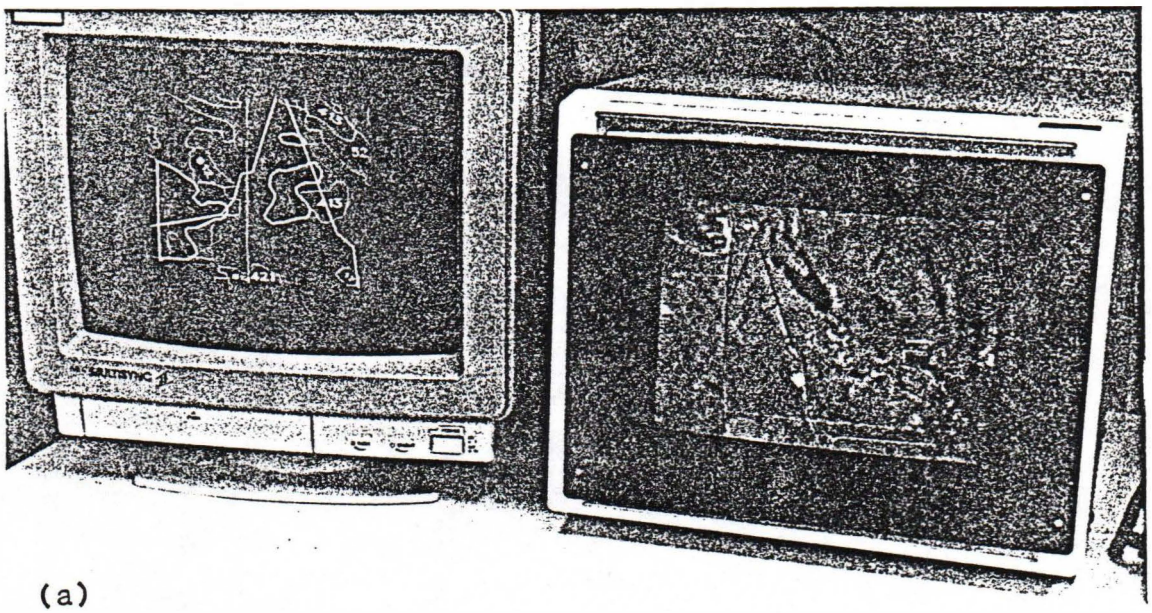


Figure 12. Defoliation polygons from Videodig (in black) overlaid with pre-existing MIRIS land cover data (in white) onto the Lake George scene.

Another useful facet of Videodig is that, like the other components of C-Map, a dBASE-compatible database file is written for all cartographic entities which are digitized (points, lines or areas). This allows database queries to be conducted either from a database management system or by graphically selecting objects on the screen. Figure 13 shows a defoliation polygon (in white) which has been selected with a point-and-click operation using the mouse; the small white circle in the polygon indicates this selection. The database pertaining to the selected cartographic object is then displayed on the monochrome monitor or can be sent to a printer (Figure 14).



(a)

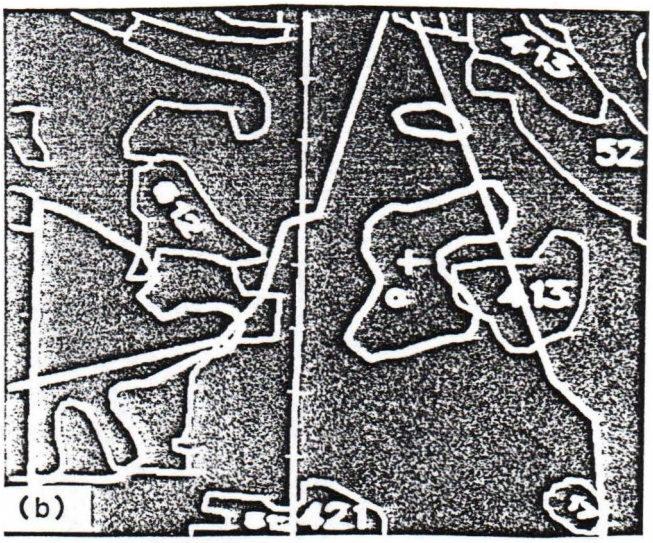


Figure 13. (a) EGA screen display (left) of MIRIS land cover (green outlines, yellow codes), pipeline (blue), and railroad (red) data overlaid with polygons of defoliation (white) which were digitized off of the rasterized video image (right). (b) Graphically selecting a particular defoliation polygon (marked with the small circle) in order to query the database concerning this entity.

```
FILE:  rept150          DATE OF LAST UPDATE: 2/20/90          RECORD No:       1
FIELDS:      17         No Editing:  <Alt-E> to Edit     TOTAL RECORDS:       9


ID              1
PERIMETER       4824.38
AREA            21.75
TYPE
REMARKS
CNTY              1
TWSP             1
ROLL              1
FRAME              1
MONTH           06
DAY             24
YEAR            89
X_COORD         1846630.37
Y_COORD         226905.68
CHARHEIGHT      94.0
CHARWIDTH       90.6
CHARANGLE       0.0


QUIT<Esc>     RECORDS<CtrlPgUP><CtrlPgDn>     FIELDS<Home><End><PgUp><PgDn>
```

Figure 14. Display of the database concerning the polygon selected in Figure 13.

The minimum hardware required for this system is an IBM PC/XT or compatible with one floppy drive, one 10 mb hard drive, MS-DOS 3.0 or above, and 640K RAM; color monitor with TARGA 16 color graphics board; [another color monitor with EGA color graphics board if the other display components of C-Map are desired]; monochrome monitor with IBM or compatible monochrome display adapter; and a serial mouse (Mouse Systems PC Mouse compatible). The system is currently running on an AT-class microcomputer as shown in Figure 15.

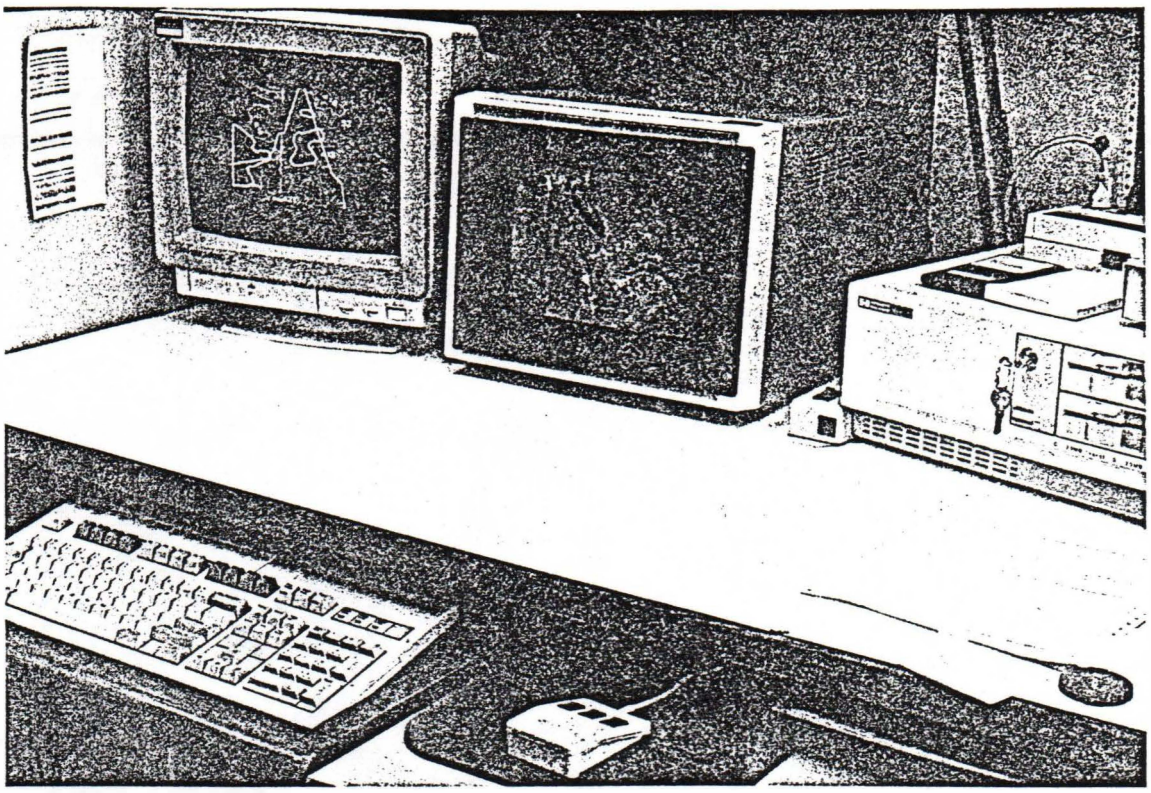


Figure 15. Current equipment installation on which C-Map Videodig has been implemented. Note the necessity of two color monitors: the TARGA 16 board displays a disconcerting level of flicker on a multisync monitor. The second color monitor in this configuration is a fixed-frequency type.

APPENDIX 1